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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 456 SEPTEMBER, 1932

DIVISION OF VETERINARY SCIENCE

Locoism in Domestic Animals

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*Dean School of Veterinary Medicine.
**In cooperation with U. S. Department of Agriculture.
†As of September 1, 1932.

This Bulletin contains information that shows that two species of loco plants, Astragalus earlei and Astragalus wootoni, occuring in the Davis Mountains region of Texas are about equally poisonous to livestock. A description of these plants with their distribution is given. The animals used in these experiments ate the plants only reluctantly, which would indicate that they eat them on the range only when other food becomes scarce. Once the animal has learned to eat these plants it forms a habit of doing so and then craves them. The dry plant is as poisonous as the green plant. The toxic principle of the plants is not excreted with the milk. The horse is more susceptible to the poisonous effects of these plants than cattle, sheep, and goats. For cattle, about 90 per cent of the animal's body weight in green loco plant is required to produce the first visible symptoms, while the consumption of about 320 per cent of the animal's weight (horses 30 per cent) in green loco plants will produce death; but when concentrates are fed with the loco plant a smaller amount of the latter is required to produce the same results. The symptoms produced manifest themselves mostly in nervous disturbances such as useless shying in horses and rearing and plunging when they are startled; while in cattle a marked trembling of the head associated with locomotor ataxia, distorted vision, a tendency to fight when agitated, and, in late stages, emaciation and cerebral depression are noted. In sheep the most prominent symptoms are cerebral depression and lassitude and, less frequently, a shaking of the head. In the goat, paralysis of the hind legs constitute the most prominent symptom. Abortions in pregnant cattle frequently follow the consumption of these two loco plants In many cases of such abortion there is excessive accumulation of amniotic fluid in the amniotic sac. The foetal membranes are much thickened on account of an accumulation of fluid therein. The uterine wall is also more or less affected. Microscopically the lesions of the central nervous system are those of an edema associated with local anemia.

CONTENTS

LOCOISM IN DOMESTIC ANIMALS*

Frank P. Mathews

The ranching industry in the Trans-Pecos section of Texas, and especially in the Davis Mountains region, has long experienced important losses among its livestock. The ranchers in this region are agreed that the major part of these losses are due to the toxic effects of loco plants. The mortalities have varied from year to year, and although authentic records for a given period are not available, evidence of the economic importance of the problem can be obtained upon meager investigation.

Since in many cases common opinion of the layman as to the cause of losses among livestock can neither be accepted nor rejected without experimental evidence, the Loco Weed Research Laboratory was established at Alpine in April, 1930, for the purpose of making an experimental study of loco-plant poisoning as it occurs in the region and for the purpose of establishing some effective methods for combating the losses from this source. The work thus far has dealt largely with determining the specific effects of feeding animals experimentally on known species of loco plant so as to thus avoid confusion of symptoms with those of other harmful plants that might be fed upon on the range. The data presented herein record the observed symptoms and effects of known species of loco plants when fed upon by animals. Experiments have been started to give some information as to practical measures for control of the loco plant under range conditions and these will be reported upon at a later date.

In spite of the fact that some species of *Astragalus*, as well as members of other genera, have been commonly known as "loco plants" from the time of the earliest settlers, the toxic nature of these plants was not proven until Marsh completed his investigations, and published the results thereof in 1909 (U. S. D. A., B. A. I. Bulletin 112). The results of his work established the relationship of *Astragalus mollissimus* and *Oxytropis lambertii* to locoism in cattle, horses, and sheep in Colorado. With the report of his investigations he also presented an extensive review of the literature, and an excellent description of the disease as it was observed in that State. Since the publication of that report, the toxic nature of similar plants and more effective methods of combatting the trouble have received but little consideration.

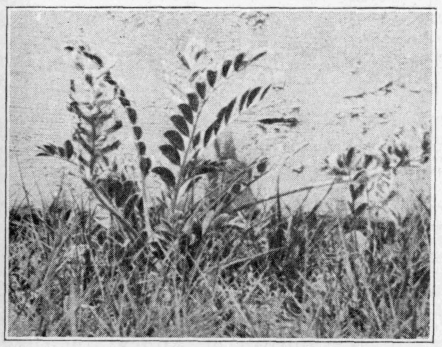

Fig. 1. **Astragalus earlei**, a young plant growing on the range.

*This work was done cooperatively by Texas Agricultural Experiment Station and the Bureau of Animal Industry, U. S. Department of Agriculture.

Several species of Astragalus are known to occur in the Davis Mountains region. However, the ranchers in this region attribute practically all their losses from locoism to the two most prevalent species, *A. earlei* and *A. wootoni. Astragalus earlei* is the more important of the two and is the one referred to by the ranchers when speaking of the loco plant. However, for shorter periods *A. wootoni* may be just as important as the other species. The data herein reported are concerned with but these two species.

BOTANICAL DESCRIPTION OF ASTRAGALUS EARLEI*

This plant is perennial, and has several rather short stems from a woody root. These stems are decumbent, densely silky-hairy, and are less than eight inches long. Each leaf consists of a number of leaflets, 19 to 29, which are arranged in pairs with an extra one at the tip, and usually is less than six inches in length, but may become nearly twice that long. The leaflets vary in size, but average about three-eighths of an inch in width and about twice that in length; they are densely hairy with mostly appressed hairs and ovate to elliptic in shape. The flowers are in axillary racemes, one to four inches long, each raceme having twenty or more flowers, usually many more than twenty. The stalk bearing the flowers and fruits is three to six inches long, while the stalk of the individual flower or fruit is very short. The calyx is cylindrical in shape, densely silky-hairy, about five-eighths of an inch long, and the awl-shaped calyx-teeth are about one-third or less the length of the calyx-tube. The corolla is purplish, and is about one inch or more in length. What distinguishes this species from other purple-flowered loco plants having a comletely two-celled pod, is that its pod is covered with short instead of long hairs. The pod is about five-eighths of an inch long, one-eighth of an inch thick, and three-sixteenths of an inch broad; it is leathery, furrowed on both sutures, acute to acuminate, incurved, and ascending or spreading.

DISTRIBUTION OF ASTRAGALUS EARLEI

The center of distribution of this species of loco plant is Jeff Davis county, Texas, from which county the type collection was made along Limpia Creek on April 25, 1902 by F. S. Earle and S. M. Tracy. It was given a herbarium name by E. L. Greene, but original description was made many years later by Axel Rydberg, who made use of the herbarium name in making publication on the species.

In the spring of 1929 a loco-plant survey of southwestern Texas and southern New Mexico was made by the U. S. Department of Agriculture under the direction of C. D. Marsh of the Bureau of Animal Industry, in Charge of Investigations of Stock Poisoning by Plants. Notes of this survey were made available to W . W. Eggleston, Associate Botanist,

*Botanical descriptions and notes on distribution were prepared by V. L. Cory, Texas Agricultural Experiment Station.

Bureau of Plant Industry (and one of the participants in this survey), who mapped the distribution of this species in Texas and courteously made the same available for use in this paper.

Astragalus earlei Greene is found in all of Jeff Davis county except the extreme western corner, in the southern tip of Reeves county, in the southwestern half of Pecos county, in the northern third of Brewster county, in the northeastern fourth of Presidio county, in that part of Culberson county lying south of the Texas and Pacific Railway, and in Hudspeth county it extends as far west as Eagle Mountain and thence on north from Sierra Blanca through the central portion of the county to the Sierra Tinaja Pinta below the New Mexico State line, but seemingly does not cross the State line here. Two isolated stations of collection are recorded on the map. These are situated in the Chisos Mountains in southern Brewster county, and in the northern part of Culberson county, east of the Guadalupe Mounains and along the State line. This latter collection by M. W. Talbot was only a few miles west of a station of collection made April 23, 1924, by V. L. Cory of the Texas Agriculural Experiment Station, which station was situated in the valley of the Black River at a point approximately one-fourth mile north of the State line, the only collection from Eddy county, New Mexico. Two collections on the eastern slope of the Sacramento Mountains are reported from Otero county, New Mexico; but its distribution in that State is quite uncertain. Likewise, its distribution in Mexico is not well-known, but it has been reported from Chihuahua.

The range in elevation is from 3700 feet in Green Valley in Brewster county up to 5600 feet in the higher mountain valleys, plateaux, and slopes. It grows both in igneous-rock soils and in limestone soils, and seems to reach its best development in draws and flats. However, it is frequently found on the higher slopes.

BOTANICAL DESCRIPTION OF ASTRAGALUS WOOTONI

The plant is annual with several stems from a woody root*. The stems are more or less erect, and are 4 to 12 inches long, and are gray with appressed hairs. The leaves are ascending, 2 to 4 inches long, and consist of 9 to 19 linear or linear-oblong leaflets, these are usually obtuse and about half an inch long, with their lower surface covered with appressed sharp straight hairs and their upper surface free from hairs. The flowers are borne in axillary racemes that are six-to-ten-flowered, the stalk of the raceme being one to two inches long. The calyx is covered with appressed straight hairs, is bell-shaped, about three-sixteenths of an inch long, the calyx-teeth and the calyx-tube being about equal in length. The corolla is pink, purplish, or white, and about five-sixteenths of an inch long. The pod is one-celled, papery, decidedly inflated, and from three-eighths to five-eighths of an inch broad and three-fourths to one inch long, and is beset with inconspicuous short straight hairs.

*Rydberg states that the plant is sometimes a perennial. In the region of the Davis Mountains it appears to be a strict annual.

This loco plant is set apart from other loco plants of Texas by its one-celled inflated pod of rather large size. A kindred species, described as *Phaca tracyi* Rydberg, from the north side of the Davis Mountains, differs chiefly in that its pod is less than nine-sixteenths of an inch long.

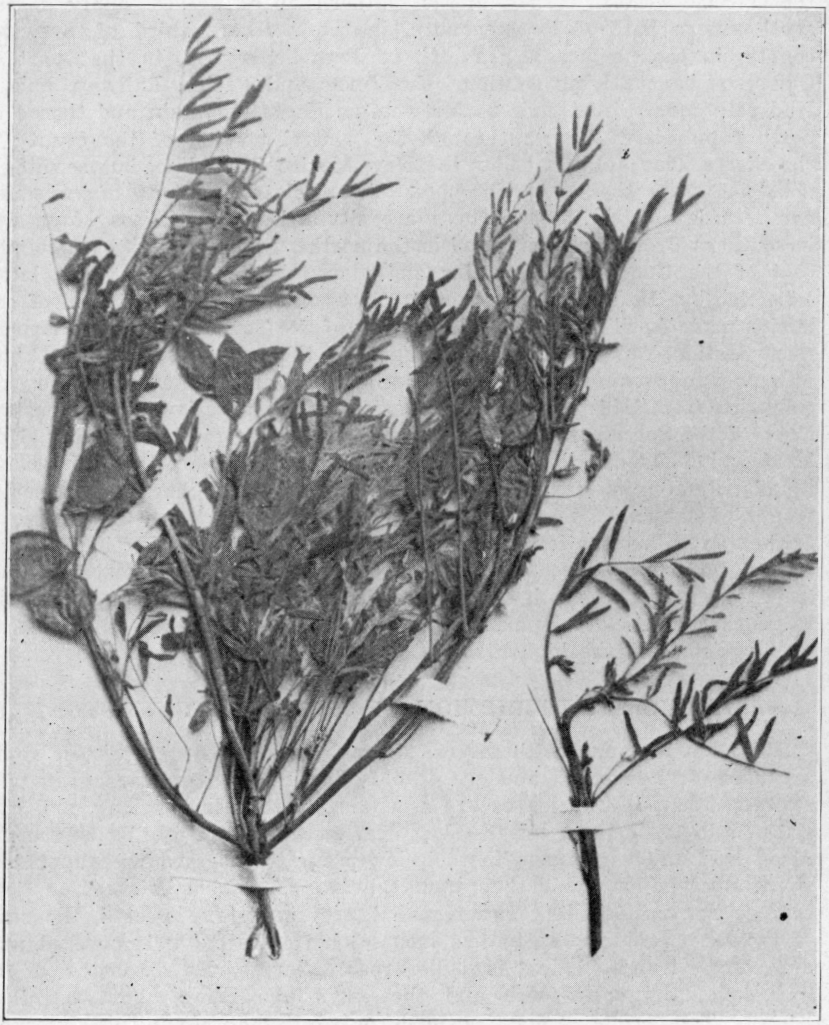

Fig. 2. ASTRAGALUS WOOTONI. A pressed specimen.

DISTRIBUTION OF ASTRAGALUS WOOTONI

The species was described from Las Cruces, New Mexico, and grows chiefly on sandy plains and hills along the Rio Grande in southern

New Mexico, in northern Old Mexico, and in the Trans-Pecos area of Texas, including mountain valleys and elevated plateaux over the western portion of that area. In the region of the Davis Mountains the plant occurs most abundantly on low areas which are flooded from the surrounding hills. Its occurrence on slopes and tops of the mountains or rocky points is confined to an occasional plant.

LOCAL CONCEPTIONS OF LOCOISM

Before the experiments herein reported were undertaken the nature of the trouble, as it was observed by local ranchers, was first taken into consideration. There was a tendency on the part of many ranchers to attribute practically all disease manifestations occuring among their livestock on the range to eating of one or the other of the two common species of loco plants. Many of the symptoms described by these men conformed to the classical description of locoism. However, such symptoms as frenzied mental disturbances, continuous walking, unusual tendencies to fight, "water belly," and sudden death, without the presence of the usual symptoms of locoism, were described with sufficient regularity to place *A. earlei* and *A. wootoni* in a unique position among the known loco plants, assuming, of course, that they were responsible for all the symptoms reported.

TOXICITY OF ASTRAGALUS EARLEI

Since the status of *A. earlei* had never been established, and since the manifestations attributed by common opinion to the toxic effects of the plant did not conform to those of locoism as observed elsewhere and due to other species of loco plants, the present experiments were conducted in order to determine the toxic nature of this plant and to obtain comparative data as to the toxic nature of both *A. earlei* and *A. wootoni.* At the same time studies of the clinical and pathological manifestations of the disease were undertaken.

For several reasons, but primarily in order to control the kind and amount of food consumption, the experiments were confined to corral feeding. Each animal was given a permanent number as soon as it was introduced into the experiment, and retained that number in any subsequent experiments in which it may have been used. Both dry and green loco plant was fed in these experiments and in order to place the results on a comparable basis the weight of the dry loco plant was converted to its equivalent of the green plant and thus recorded. All computations are made on the basis of a seventy per cent loss in weight during drying. A summarized history of each animal employed in the investigation is given in Table 1.

The object of the first experiment (Cattle 1 to 16) was to compare the toxicity of green *A. earlei* with that of dry *A. earlei.* Sixteen head of cattle, ranging from eight to fourteen months of age, were employed for this phase of the investigation. The cattle were divided into four

Table 1. Toxicity of **Astragalus earlei** and **Astragalus wootoni**

No. of animal	Animal wt. lbs.	Loco plant fed lbs.	Feeding period days	Prairie hay, lbs.	Grain or cake lbs.	Results
Toxicity of **Astragalus earlei**						
Cattle						
2	380	1320	98	274		Locoism-death
3	380	150	46	95		Quit eating loco plant
4	370	320	82	263		Moderate locoism
5	320	410	69	95		Quit eating loco plant
6	310	180	40	95		Quit eating loco plant
10	320	1086	107	263		Marked locoism
11	350	980	81	310		Moderate locoism
12	380	1430	112	278		Locoism-death
13	220	495	107	250		Locoism-death
14	190	530	81	98		Locoism-death
15	230	690	114	270		Locoism-death
16	240	25	19	76		Died-cause undetermined
17	645	80	32	139		Died-peritonitis
19	675	724	77	557	288	Marked locoism
20	630	763	94	851	374	Marked locoism
21	675	358	107	610	98	Locoism-abortion
22	925	358	107	610	98	Locoism-abortion
23	790	358	107	610	98	Locoism-abortion
Horses						
1	890	193	40	332		Sudden death
2	850	268	49	397		Locoism-sudden death
3	660	313	61	340		Locoism-sudden death
4	750	128	47	241		Refused to eat
5	925	141	101	ad lib.	195	Locoism-sudden death
Sheep						
1	75	58	69	88		Marked locoism
2	60	116	69	70		Marked locoism
3	73	146	59	44		Marked locoism
4	65	195	59	28		Marked locoism
5	77	235	53	27		Marked locoism
6	70	230	53	27		Locoism-death
Goats						
1	70	.....	36	.....		Refused to eat
2	80	.....	36	.....		Refused to eat
3	55	125	53	38		Marked locoism
4	80	.....	42	.....		Refused to eat
5	68	235	54	27		Marked locoism
6	52	230	54	27		Marked locoism-death
Toxicity of **Astragalus wootoni**						
Cattle						
19	725	591	62	506	186	Marked locoism
23	690	53	30	..	..	Refused to eat
30	700	436	38	475	220	Moderate locoism
Sheep						
2	55	48	51	51	.....	Marked locoism
5	72	149	47	32	.....	Locoism-death
7	75	3	40	.....	.....	Refused to eat
8	70	6	40	.....	.....	Refused to eat
9	68	5	24	.....	.....	Refused to eat
10	85	5	32	.....	.....	Refused to eat
11	65	11	36	.....	.....	Refused to eat
Goats						
1	70	59	33	18	.....	Locoism-starvation
2	67	63	37	5	.....	Locoism-starvation
3	60	19	33	35	.....	Locoism-starvation-death
5	70	29	36	4	.....	Locoism-starvation-death

Note:—The weight of the dry plant is expressed in its equivalent of green plant.

lots with four animals to the lot. The animals in lots 1 and 2 were fed individually. The daily ration of loco plant for the animals in lot 1 consisted of .3, .6, .9, and 1.2 per cent respectively of their body weight of the dry plant. Lot 2 received 1, 2, 3, and 4 per cent respectively of their body weight as part of their daily ration of the green plant. The animals in lot 3 were allowed to run together and eat at will from a manger full of dry loco plant; a fresh amount of the plant was weighed into the manger each morning and the unconsumed portion weighed back the same night. In addition to the loco plant, all animals were fed prairie hay in sufficient amounts to make a total daily ration of 7.5 pounds of dry feed, or the equivalent of that amount. In some cases the hay had to be withheld in order to force the animals to eat the required amount of the loco plant. Lot 4, a control lot, received 7.5 pounds of prairie hay per head daily. The animals in this lot are not listed in Table 1, and are given no further consideration since they remained healthy throughout the experiment. The results of the first experiment are sumarized in Table 2.

Table 2. Comparative Toxicity of Green and Dry **Astragalus earlei**

No. of animal	Animal weight pounds	Feeding period days	Loco plant fed, lbs.	Per cent of body weight	Condition of plant	Results
Cattle 13 4, 10,	303	98	634	209	green	Locoism
Cattle 2, 11, 12, 14, 15	308	98	990*	320	dry	Fatal locoism

Note: Figures represent averages of data submitted in Table I.
*Two hundred and ninety-seven pounds of dry plant were fed.

In this experiment dry loco plant to the extent of 320 per cent of the body weight of the animal (figured on the basis of its equivalent weight of green) was sufficient to produce lethal, toxic effects. In the case of the green plant 209 per cent of the body weight was sufficient to produce marked symptoms of locoism, but did not constitute a lethal dose. Had the supply of the green plant remained available, its consumption would probably have been increased to a figure very closely approximating that obtained with the dry plant by the time fatal results would have been produced. The amount of loco plant required to produce the first recognizable symptoms varied within rather wide limits, but averaged about 90 per cent of the body weight regardless of whether the green or the dry plant was fed. The time required for the appearance of such symptoms was approximately 60 days when loco plant was fed ad libitum and slightly longer when the daily consumption was restricted.

Three of the animals in lot 1 ate their daily ration of dry plant for a period of four to six weeks, but thereafter refused to eat it. As they showed no evidence of toxic effects they had to be excluded from the final summary. Since this left but the one animal in this lot, it was necessary to include the results with this animal with the results obtained by feeding

the dry plant ad libitum in order to obtain sufficient data to make a comparison of the results of feeding the green and the dry plant. The experimental conditions are, therefore, not identical in both cases, as the green plant was fed in definite amounts depending upon the weight of each animal. This deviation is of but slight importance, as a comparison of the toxic content of the green plant with that of the dry plant was obtained. From the results obtained it is evident that there is little or no loss in toxic content associated with drying the plant.

COMPARATIVE TOXICITY OF ASTRAGALUS EARLEI FOR CATTLE, HORSES, SHEEP, AND GOATS

In conjunction with the first experiment, similar feeding tests were conducted with horses, sheep, and goats. The results of these tests are summarized in Table 3.

Table 3. Comparative Susceptibility of Cattle, Horses, Sheep, and Goats to **Astragalus earlei.**

Animals	Animal Weight pounds	Feeding period days	Loco plant fed pounds	Per cent of body weight	Results
8 cattle	306	98	856	280	Locoism
4 horses	878	49	225	30	Locoism
6 sheep	70	60	164	234	Locoism
3 goats	59	54	198	335	Locoism

Note:—Figures represent averages of data submitted in Table 1.

The results of these experiments as repretsented by figures in Table 3 clearly demonstrate the pronounced susceptibility of the horses as compared to the susceptibility of the cattle, sheep, and goats, to the toxic principle of *A. earlei.* The susceptibility of cattle and sheep was about the same, but the goats appeared to be little less sensitive to the toxic principle. However, the results were obtained with but three goats, thus introducing the possibility of a rather high experimental error. More recent experiments, incomplete at this time, indicate that cattle, sheep, and goats are about equally susceptible.

A critical stage of the disease was indicated by an abrupt decrease in the daily consumption of the loco plant. The difference in the amount of loco plant expressed in terms of per cent of the body weight which was required to produce a critical stage of the disease, or fatal toxic effects, was very small (about ten per cent). Therefore, the susceptibility of the cattle, horses, sheep, and goats was placed on a comparable basis, regardless of the fact that fatal, toxic effects were produced in all the horses, and in but part of the cattle, sheep, and goats. The experiments were terminated when a critical stage of the disease had developed in some of the animals in order to save them for other experiments.

THE TOXICITY OF ASTRAGALUS EARLEI WHEN FED WITH PRAIRIE HAY AND CONCENTRATES

In the first experiment it was evident that a starvation factor over which there was no conrol had been operating. Since the influence of

this factor upon the development of the disease was unknown it was desirable to have some experimental proof of its importance before a final interpretation of the resutls could be made. The results of this work are summarized in Table 4. As will be noticed in this table, a surprisingly small amount of loco plant was required to produce death, or a critical stage of the disease in both the cattle and the horse when concentrates were fed in addition to the ration of loco plant and hay. In the case of the cattle 280 per cent of the body weight was required in the absence of concentrates, and only 69 per cent when grain or cottonseed cake was added. With the horse the difference was not quite as great, 30 per cent being required in the absence of concentrates, and 10 per cent when grain was added to the ration. An interpretation of these results must be governed to some extent by a consideration of the factors previously mentioned. However, individual susceptibility appears to be inadequate for an explanation of the wide variation observed in these results.

Table 4. Toxicity of **Astragalus earlei** when fed with prairie hay, and when fed with prairie hay and concentrates (corn and wheat bran or cottonseed cake)

Animals	Initial weight pounds	Feeding period days	Loco plant fed pounds	Per cent of body weight	Ration	Results
8 cattle	306	98	856	280	hay and loco plant	Locoism
5 cattle	739	98	512	69	hay, loco plant, concentrates	Locoism
4 horses	787	49	225	30	hay and loco plant	Locoism
1 horse	925	101	141	10	hay, loco plant, concentrates	Locoism

Note:—Averages obtained from figures given in Table 1.

TOXICITY OF ASTRAGALUS WOOTONI

The common opinion of ranchers throughout the Davis Mountains area endows *A. wootoni* with much greater toxicity than is possessed by *A. earlei.* They frequently maintain that sudden death without visible symtoms of locoism are associated with eating of the former plant. A summary of the results of feeding *A. earlei* and *A. wootoni* is presented in Table 5.

A smaller number of animals was used to test the toxicity of *A. wootoni* than was employed for similar work with *A. earlei.* Cow 19 and sheep 5 had been fed *A. earlei* in previous experiments but had made partial recoveries from the effects of this plant before they were fed *A. wootoni.* Cows 19 and 30 were fed hay and cake in addition to the *A. wootoni.* A comparison of the results obtained in this experiment (Table 5) with the results obtained by feeding *A. earlei* under like conditions shows from a practical standpoint, the two plants to be about equal in toxicity. In spite of the fact that cattle 19 and sheep 5 had but partially recovered from the toxic effects of *A. earlei,* they were able to tolerate about the same amount of *A. wootoni* as they had of the *A. earlei.* Cow 30 had no history of previous contact with loco and tolerated 65 per cent of the body weight of *A. wootoni.* The results with goats are not listed in this table on account of the fact that although they were showing marked symptoms of locoism at the time of death, it was quite evident

that starvation contributed as much to the results as did *A. wootoni* since the other food was frequently withheld in order to force them to eat the plant. Another experiment with sheep, which had no history of previous contact with *A. earlei* was attempted in order to test the toxicity of dry *A. wootoni*. Without exception the five animals in this experiment preferred to starve rather than eat the plant. Throughout all the tests with *A. wootoni* the animals as a whole showed a greater reluctance to eat this plant than was shown in previous experiments with *A. earlei*. The symptoms produced with the two plants were identical.

Table 5. Comparative toxicity of **A. earlei** and **A. wootoni** for Cattle and Sheep

Animals No.	Initial average weight	Feeding period days	Plant fed	Plant fed pounds	Per cent body weght	Results
Cattle 19*, 30	713	60	A, wootoni	513	71	Critical locoism
Cattle 19 to 23	739	98	A. earlei	512	69	Critical locoism
Sheep 5*	72	47	A. wootoni	149	207	Critical locoism
Sheep 1 to 6	70	60	A. earlei	164	234	Critical locoism

Note:—Figures represent averages of data submitted in TableI.
*Partial recovery from intoxication by **A. earlei** before being fed **A. wootoni.**

THE EFFECTS OF ASTRAGALUS EARLEI ON REPRODUCTION

In referring to Table 1 it will be noticed that abortion occurred in cattle 21, 22, and 23. All three animals had been showing marked symptoms of locoism for three weeks prior to the first abortion by cow 22, which occurred on the 77th day of the experiment. Cow 23 aborted on the 82nd day of the experiment and cow 21 on the 109th day of the experiment. These three animals were the only pregnant animals employed in the investigation thus far; a 100 per cent abortion rate was thus observed. In these cases serologic tests for infectious bovine abortion (Bang) were negative. Furthermore the gross pathology was quite different from that of Bang's disease.

Sexual desire in the bull and estrus in cattle were suppressed about the time toxic effects appeared and remained suppressed as long as the animals continued to eat the plant. As soon as the physical condition began to improve, following deprivation of the plant, these physiological functions returned to normal. That fertility was not seriously impaired is shown by the following results: Three cows which had partially recovered from the effects of eating the plants were mated to a bull with a similar history. The three cows conceived and are with calf at the present time. Two nanny goats that had partially recovered were bred to a healthy male, and conception in both cases was followed by full-time gestation periods.

TOXIC PRINCIPLE PROBABLY NOT EXCRETED IN THE MILK

The fact that the toxic principle in some poisionous plants is eliminated in the milk prompted the question as to whether or not this condition pre-

vailed in the case of locoism. Two pregnant milk cows were therefore selected for this investigaton (Cattle 20 and 30, Table 1). The cows were fed on alfalfa hay and cake until the time of calving, at which time one of the animals was placed on a ration of *A. earlei*, prairie hay, and cottonseed cake. The other was fed the same ration except that *A. wootoni* was substituted for *A. earlei*. Prairie hay was used in place of alfalfa on account of the fact that in the experimental pens the animals invariably ate the loco plant with greater reluctance when being fed alfalfa than when prairie hay was used. The calves were allowed to nurse the cows morning and night. The remainder of the time they were isolated in order to avoid any possibility of their eating the loco plant that was fed to their mothers. *Astragalus earlei* was fed for a period of 94 days; *A. wootoni* for 58 days. At the end of these periods both cows were showing marked symptoms of locoism, and the feeding of the plants was discontinued in order to prolong the life of the animals. The calves were allowed to nurse until they were six months of age and at no time showed any evidence of locoism.

WEIGHT OF ANIMALS DURING DEVELOPMENT OF LOCOISM

An initial loss in the body weight was generally observed during the period required to overcome the natural reluctance on the part of the animals to eat the loco plant. When the animals finally would accept the plant and when a bare maintenance ration of 7.5 lbs. of dry feed of which the loco plant constituted a part was supplied, the weight of the animals gradually declined but not appreciably more than that of the control animals on the same ration of hay without loco plant. When, however, the ration was more nearly adequate and included concentrates in addition to the roughage and loco plant, the initial loss in weight was observed as in other cases, but this loss was soon regained and the weight of the animals continued to increase from the time they began to eat the loco plant with avidity until the critical stage of the disease had developed, thus showing that starvation or malnutrition, although frequently observed in these experiments, is not essential to the development of the clinical picture, prior to the critical stage of the disease.

The weights of a number of animals during the test period are given in Tables 6, 7, and 8. The scales employed for the first experiment (Table 6) were shipping-pen scales and quite inaccurate for individual weights. On this account the average weights for the animals in each lot are given in place of of individual weights. The remainder of the weights were obtained with platform scales, which were later installed at the corrals. The first weights were obtained on the animals listed in Table 6 when they were placed on experiment; the last weight after marked symptoms of locoism had developed, but before the critical stage of the disease manifested itself. In the case of the animals listed in Tables 7 and 8 the first weights were obtained at the beginning of the experiment, the last about a week to ten days after the critical stage of the disease had developed. The final weight shows the loss in weight which occurred in

the late stages of the disease, and which is associated with a decrease in daily food consumption, although these animals had not entirely quit eating when the last weight was taken.

Table 6. Average weight of cattle showing loss or gain when fed **A. earlei** and prairie hay. Four cattle to each lot, 1930.

Lot No.	Cattle	Fed	May 13	May 26	June 16	June 30	July 22
1	5, 14, 3, 6	Dry plant	300	325	307	315	280
2	13, 10, 4, 16	Green plant	303	306	300	320	306
3	11, 12, 15, 2	Dry plant	340	315	322	332	310
4	1, 7, 8, 9	Prairie hay only	400	390	------	422	387

Table 7. Loss or gain in weight of cattle fed concentrates in addition to **A. earlei** and prairie hay, Nov. 1930 to Feb. 1931

Cattle Number	Nov. 4	Dec. 4	Dec. 24	Jan. 31	Feb. 22
19	675	670	730	760	665
21	670	615	690	750	650
22	925	800	845	905	870
23	790	745	780	785	620

Table 8. Loss or gain in weight of sheep and goats fed **Astragalus earlei** and prairie hay, 1930

Animal Number	Oct. 16	Nov. 4	Dec. 4	Dec. 23
S1	75	65	50	----
S2	60	55	50	50
S3	73	60	60	55
S4	65	70	55	----
S5	77	65	60	50
S6	70	75	65	35
G3	55	60	55	60
G5	68	65	60	60
G6	52	60	50	----

SYMPTOMS OF LOCOISM

From the historical account of locoism by ranchmen and others, Marsh (Bul. 112, B. A. I., U. S. D. A.) tabulated a list of 51 different symptoms, many of which were of such a contradictory nature as to suggest erroneous conclusions by many of the observers. Within this rather imposing list there was a fairly constant agreement upon six symptoms, namely, a slow staggering gait, rough coat, staring look, emaciation, muscular incoordination, and extreme nervousness. Marsh's investigations proved that these six symptoms were characteristic of loco-plant poisoning. In addition to these symptoms he observed that solitary habits, a dullness which could be changed to frenzy by agitation, difficult drinking, and distorted vision, were exhibited by animals which were poisoned either by *A. mollissimus* or *O. lamberti.* Since there was no detectable change in the structure of the eye he attributed the distorted vision to some change in the central nervous system. The extreme nervousness as evi-

denced by useless shying, or rearing and plunging when the animal was startled was observed much more frequently in horses than in cattle or sheep. A shaking of the head, like the hand of a palsied man, was especially noticeable in cattle. In sheep the outstanding symptoms were weakness and depression. The disease in goats appears to have been studied but little; Marsh reported observations on only one field case.

The symptoms of locoism due to the consumption of *A. earlei* and *A. wootoni* as observed thruoghout the course of the experiments herein reported, with few exceptions, were the same as those observed by Marsh. In the horse a listless attitude which was easily changed to a frenzied rearing and plunging when the animal was startled, was a characteristic manifestation. The uncontrollable shaking of the head on a horizontal plane, associated with locomotor ataxia, and a distorted vision were diagnostic symptoms in cattle. In some cases moderate agitation of cattle in advanced stages of the disease, was followed by frenzied attempts to attack the agitator. In sheep the toxic effect was manifested by cerebral depression and lassitude; shaking of the head was not constant and only shown in late stages of the disease.

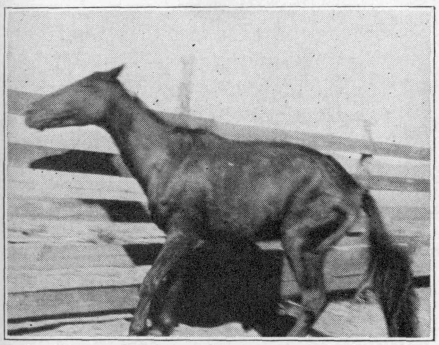

Fig. 3. A locoed horse after being startled.

The first symptom observed in goats was a weakness of the hind legs, but the weakness was not shown until the animals were startled. During this stage of the disease there was nothing abnormal in the movements of the animals as they walked about the pens, but when they attempted a quick movement there was a transitory paralysis of the extensor muscles of the hind legs, which caused the rear quarters to drop to the ground. A variable period would elapse before such an animal could regain an upright position. As the strength returned to the hind legs the animal would move off with a flexed hock, and the hind quarters would weave to the right and to the left for several steps

Fig. 4. Cow showing an early symptom of locoism, the tendency to fight.

before complete control of the hind limbs was regained. As the toxic effects progressed, extension of the hock joint became increasingly difficult; the animals frequently stood erect on the fore legs with the hocks resting on the ground. This attitude resembled the attitude of posterior paralysis in swine. In advanced cases a definite paralysis developed in the hind legs and a paresis appeared in the fore limbs; however, considerable use of the fore limbs was retained until a day or two before death. Shaking of the head was not a constant manifestation and was observed only in advanced cases. If an animal with a well established case was held by the horns a rythmic twitching of the eye ball was observed, the eye ball being moved in a horizontal plane; at its greatest deflection the pupil was partially hidden behind the outer canthus of the eye. Another prominent symptom in advanced stages of the disease consisted of supporting the weight with the fore legs, the hind quarters resting on the ground with the head drawn back toward the spinal column as if attemting to turn over backward. This manifestation is very similar to the opisthotonos which is produced in chickens by a vitamin B deficiency. The animals retained a bright facies until a few days before death and exhibited none of the cerebral depression which was so pronounced in sheep.

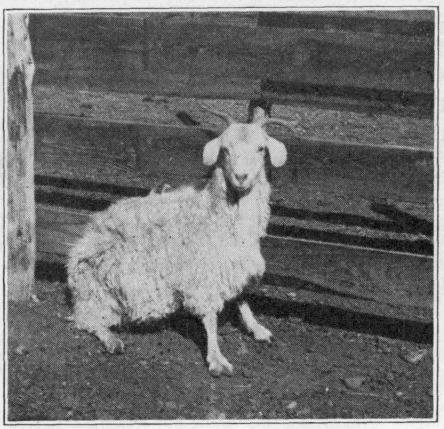

Fig. 5. Goat showing first symptoms of locoism; paresis of the hind legs.

Fig. 6. Same animal as in Fig. 5 five days later; now showing paralysis of hind legs and paresis of fore legs.

In addition to the typical symptoms of locoism in cattle there were other manfestations of the disease, which, although not constantly observed, should evidently be considered as part of the clinical syndrome. The most important of these were conjunctivitis, keratitis, and excessive lacrimation. About fifty per cent of the animals in the experimental pens were thus affected and these recovered completely without treatment after several weeks, although the loco continued to be part of the ration. The condition was much more pronounced among the animals fed the dry plant than in

those fed the green plant.

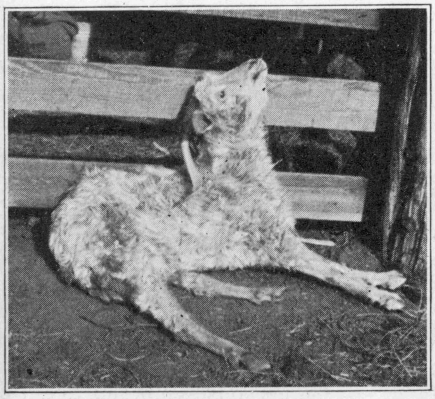

Fig. 7. Goat showing opisthotons in advanced stage of locoism.

The control animals were not affected. A similar involvement of the eye is quite prevalent on the ranges and has been observed with much greater frequency among known "loco eaters" than in cattle which have shown no evidence of locoism. The inflammatory condition of the eye is probably produced by dust from the plant, as the dust is very irritating to the eye of man. It is evidently not a mere mechanical irritation but is due to some irritating substance within the dust particles. Further consideration of this phase of the subject will be found in the discussion.

Another clinical aspect of the disease, but one upon which less clear-cut evidence has thus far been obtained, is the so-called "water belly"*, or "big belly." This condition is characterized by a distention of the abdomen of pregnant cattle until the abdomen resembles that of an animal with a ruptured prepubic tendon. The distention is due to edema of the foetal membranes and an enormous quantity of amniotic fluid, but not to ascites as is suggested upon first observation. On the ranges this condition has been observed only among known "loco eaters" in advanced stages of pregnancy; the same animals have shown little or none of the other toxic effects. The pregnant animals used in the corral feeding experiment developed an edema of the foetal membranes without the distention of the abdomen. In the corrals the pregnancies were terminated at about five months or a little less, which may be an important factor in the failure to produce a typical case of so-called "water belly." In spite of the fact that all the factors concerning the production of this condition are not recognized at this time, it is evident that it is associated with the eating of loco plants.

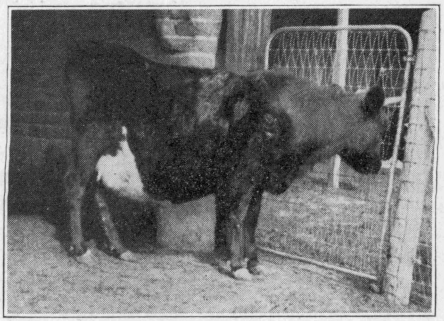

Fig. 8. A field case of so-called "water belly."

*The condition here observed and erroneously called "water belly" by the ranchmen must not be confused with a condition observed among steer calves in the Panhandle Region of Texas where plants do not always occur. Calves in this condition show a large accumulation of liquid within the abdominal cavity.

It is generally conceded that "locoed" cattle will make at least a partial recovery and can be fattened for beef, if they still possess sufficient mentality to eat nutritious food when they are deprived of loco plants. That this is not an infallible rule was demonstrated by two experimental animals. Both of these animals had been eating green *A. earlei*, one of them in a corral, the other in a pasture, and although showing marked symptoms of locoism they were strong and active when further access to loco plants was prevented. For one week following the further access to loco plants, both animals showed a pronounced cerebral depression, which they had not shown prior to this time. As the cerebral depression disappeared, both cattle showed an increasing desire to eat alfalfa and cottonseed cake, and at the same time a slight decrease in the nervous symptoms occurred. Both animals ate well and appeared to be improving for a period of six and eight weeks respectively, when it was noticed that they were now experiencing difficulty in prehending food and water. These symptoms gradually became more pronounced and at the same time the nervous symptoms again became intensified. Both animals developed the most pronounced symptoms of locoism which have ever been observed by the writer and since they became practically helpless they were killed on the second and third months respectively after further access to loco plants was prevented. In these cases the maximum effects of loco-plant poisoning were obtained two and three months respectively after the last loco plant was eaten.

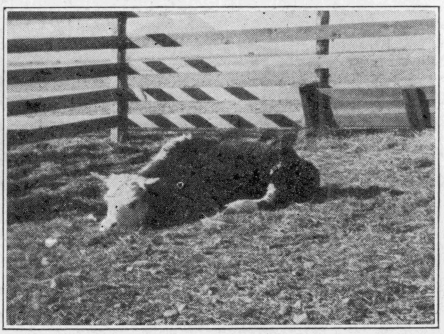

Fig. 9. Cow showing cerebral depression which occurred after loco-plant feeding had been discontinued.

GROSS PATHOLOGY OF LOCOISM

The historical account of locoism was as replete with opinions concerning the pathology as it was concerning the symptoms of the disease, forty-two different changes having been recorded by various observers. In the light of present knowledge, few if any of the lesions recorded in this list can be considered as at all significant. The most constant lesions observed by Marsh were anemia, ulceration of the abomasum of cattle, and ulceration or congestion of the stomach of the horse. Other changes consisted of "prominent hemolymph nodes," hyperemia of the brain, serous exudate into the epidural spaces, and atrophy of the ovaries.

From my observations on forty-eight autopsies (horses, cattle, sheep, and goats) which have been performed on experimental and field cases of locoism it is evident that a pathognomonic lesion does not exist, with the possible exception of a change in the pregnant uterus and foetal membranes of cattle. The walls of the gravid uterus of the cow showed a

mild edema, but the principal change was found in the maternal cotyledons and the foetal membranes. The maternal cotyledons had the size and appearance which are generally observed within a uterus after about one-half the stage of normal involution has passed. The foetal membranes were quite edematous. In extreme cases they were between two and three inches thick and of a gelatinous consistency. The attached surface of the foetal cotyledons had a macerated, greenish appearance quite different from the dirty yellowish cast observed in the foetal membranes from a case of Bang's disease. In the case of abortion due to locoism the foetus showed considerable maceration thus suggesting that death had occurred some time before expulsion was attempted. Aside from these changes in the pregnant uterus there is little to be added to the observations by Marsh. There was a mild generalized edema of the subcutaneous connective tissue and serous infiltrations frequently gave the porous bones of the cranium a water-logged appearance. In ruminants the abomasum showed a marked edema of the mucosa and frequently, ulcerations around the pylorus. The same condition was also observed in the stomach of the horse. Incidentally the lesions in the stomach heal very quickly after further access to loco plants is prevented. Hyperemia of the brain was not observed. On the contrary if any changes had occurred in the circulatory system of the brain they were represented by anemia and edema. However, such changes were never sufficiently well marked to enable one to make a definite statement to this effect. The anemia of the brain was a local change and not due to a generalized anemia. No clots of blood or serum were found in the cerebral ventricles.

MICROSCOPIC PATHOLOGY OF LOCOISM

The microscopic changes in the foetal membranes were about what one would expect to find in any case of pronounced edema. In addition to the swollen appearance of the tissue there was a mucoid degeneration of the supporting connective tissues within the chorionic villi. The muscular portion of the uterine wall showed nothing but a mild edema, but considable change was observed in the mucosa. The peripheral portion of the uterine glands was lined with normal epithelium but the remainder of the mucosa was entirely denuded of epithelium. The normally loosely arranged stroma of the uterine mucosa was transformed into a band of compact connective tissue with no apparent increase in the number of blood vessels. There was no evidence of a leucocytic infiltration in either the uterine wall or the foetal membranes. The outstanding histopathology was, therefore, a fibroblastic proliferation within the mucosa of the uterus and sloughing of the epithelium. These changes are evidently later repaired but the time required for the reparation is not known.

The changes in the stomach were confined to the mucosa, the stroma of which was very much thickened on account of the edema. Within the ulcerated areas there was but slight depression, as the absence of epithelium was compensated for by newly formed connective tissues. Blood-vessel formation had not kept pace with fibroblastic proliferation. In

fact there was very little evidence that angeoblastic proliferation had occurred. The leucocytic response in these areas was mild and consisted of large mononuclears and plasma cells; polymorphonuclear infiltration was not observed. The remaining viscera showed about the same degree of atrophy that can be found in any case of partial starvation.

Sections were taken from the various parts of the brain, medula, and from several locations in the cord for microscopic studies of the central nervous system. Tissues were fixed in both formaldehyde and Mueller's solution, imbedded in parrafin, and stained with hematoxylin-eosin and by Van Gieson's method. The sections showed a uniform change, which is evidently part of the picture of generalized edema. This change was best demonstrated with formol fixation and hematoxylin-eosin staining. With this preparation the cytoplasm of the large motor cells failed to take the faint basic stain which is generally observed in this type of cell in the normal brain. The chromophilic granules were well stained and especially prominent on account of the unstained background. Cells showing this change generally had a swollen appearance and their boundaries

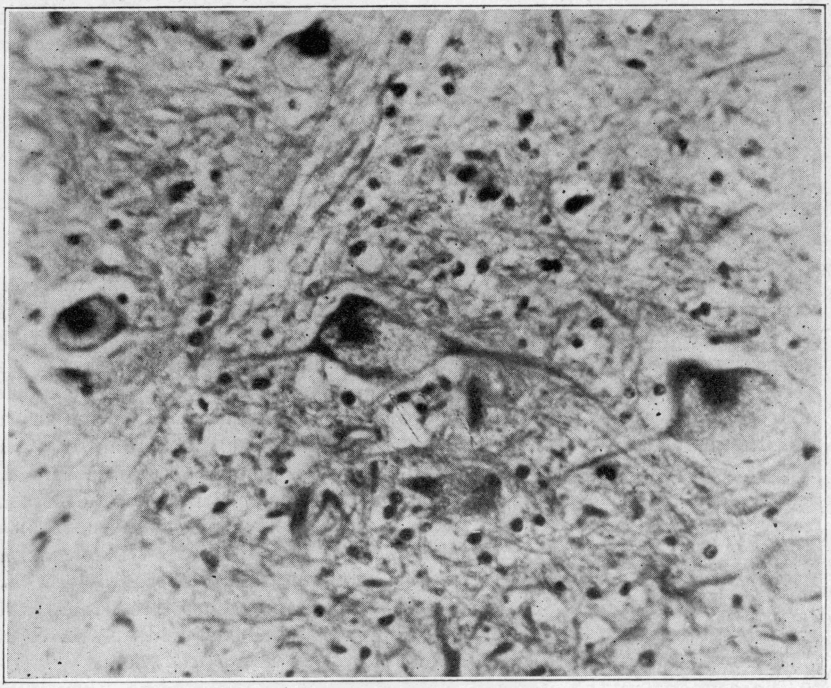

Fig. 10. Photomicrograph of a section from the medulla of a locoed cow, showing large nerve cells with unstained cytoplasm, prominent chromophilic granules, and more shrinkage than is generally observed. (H. & E. Stain).

remained in contact with the surrounding glia, thus showing little or none of the shrinkage which generally occurs in similar preparations from a

normal subject. Rarely did all the cells of this type show the same degree of change. Many intermediate stages between the normal staining reaction and the one just described could generally be demonstrated in the same section. The swollen appearance and the absence of stain in the cytoplasm was also observed in the cells of Purkinje.

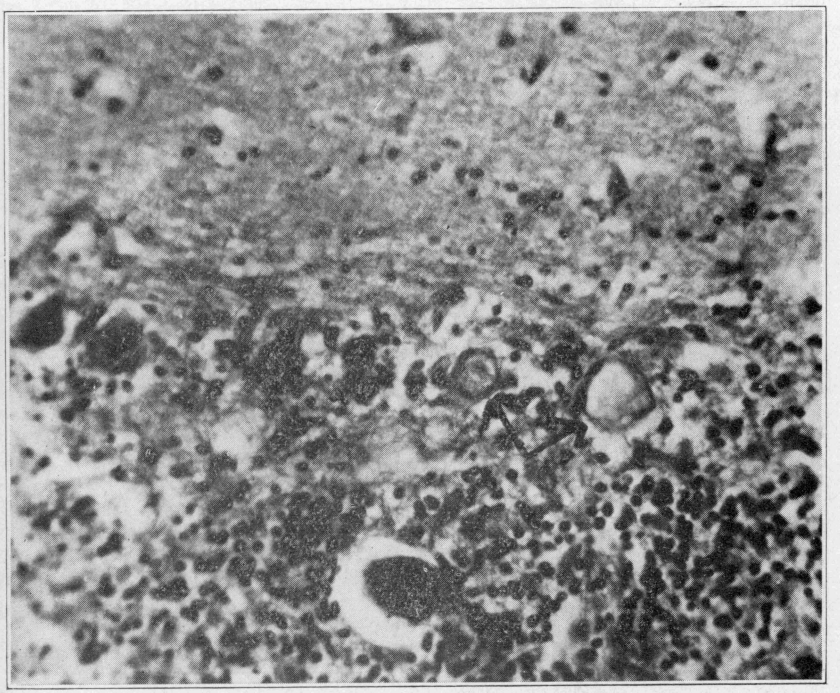

Fig. 11. Photomicrograph of a section from the cerebellum of a locoed cow, one swollen cell of Purkinje, another with slight change, and several with no change.

There was a vacuolation of many of the nerve cells of the cerebrum and especially of the hippocampus. The cytoplasm was entirely unstained, the boundaries of the cells were in contact with the surrounding glia, and the nuclei were crowded towards the periphery of the cells. The medullary nerves in many localities of the central nervous system showed a slight swelling of the medullary sheath. However, this swelling was never of sufficient magnitude to be satisfactorily demonstrable by photomicrography. The number of red blood corpuscles within the vessels was uniformly scanty thus supporting the suggestion of anemia which was noted upon autopsy. It was of interest to note that the changes in the central nervous system were not permanent, as they could no longer be demonstrated shortly after the eating of the loco plant was discontinued.

The changes noted in the central nervous system of cattle, horses,

sheep, and goats were also observed in the central nervous system of three cats. The cats had been fed on extracts of *A. earlei* and were showing marked symptoms of locoism at the time of autopsy.*

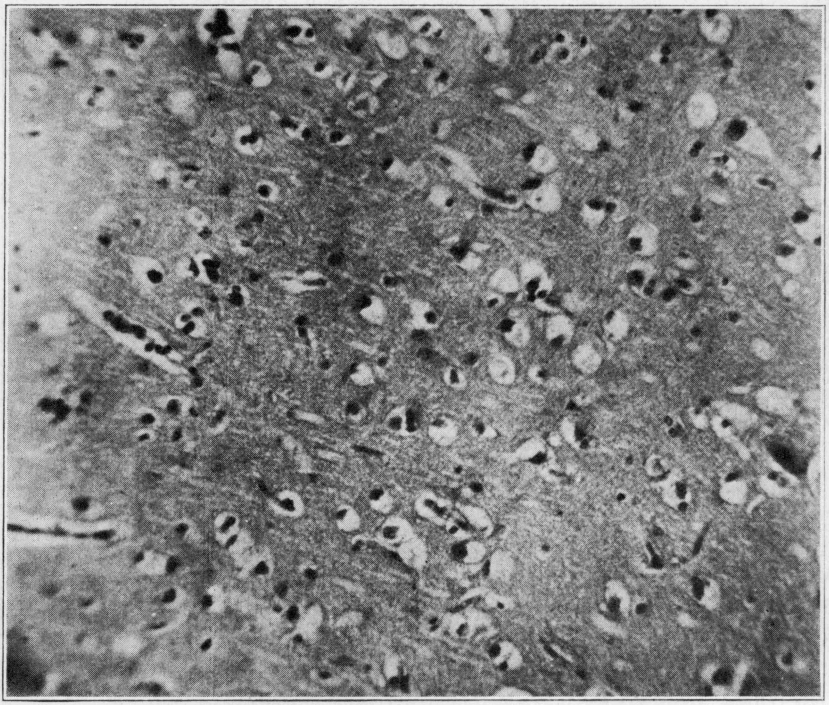

Fig. 12. Photomicrograph of a section from the cerebrum of a locoed sheep, showing vacuolation of the nerve cells.

Red-blood-corpuscle determinations were made on the blood of twelve cattle, six sheep, and six goats. The first determinations were made at the time the animals were placed on experiment, the second after well marked symptoms of locoism had developed. The time between the first and second counts varied from sixty to ninety days. The average red-cell content of the blood for the cattle was 9.0 million per cu. mm. for the first counts and 8.9 million after locoism had developed. The average for goats was fourteen million and for sheep eleven and one-half million on the first count. After toxic effects had appeared it was thirteen and one-half million for the goats and eleven and eight-tenths million for the sheep. In no case was there sufficient drop in the red-blood-corpuscle content of the blood to justify the diagnosis of a general anemia.

*The cats were some of the experimental animals of Dr. G. S. Fraps, Chief, Division of Chemistry, Texas Agricultural Experiment Station.

DISCUSSION

The disease produced in the foregoing experiments consisted of a neuropathology manifested by muscular incoordination, which increased in severty as the disease progressed. In the terminal stages there was a cerebral depression and refusal of all food for a few days preceding death. Therefore, with minor exceptions the disease produced by feeding both *A. earlei* and *A. wootoni* did not differ materially from that caused by feeding *A. mollissimus, O. lambertii,* etc. in other localities. The results therefore indicate that, in the absence of characteristic symptoms of locoism, such symptoms as violent mental disturbances, continuous walking and sudden death, which are observed in range cattle and attributed by ranchmen to the eating of the loco plants under investigation are in all probability the result of some other disease-producing agent.

Since the two species, *A. earlei* and *A. mollissimus,* are quite closely related it was not surprising to find that the symptoms produced by feeding *A. earlei* were about the same as those produced by feeding *A. mollissimus.* However, some difference was observed in the economic aspects of the two plants. Marsh observed that where *A. mollissimus* was the predominating species the problem of locoism was practically confined to horses, cattle being rarely affected. In his experimental work he was able to produce locoism in horses, but cattle were found to starve rather than eat the plant. He also observed that when the problem of locoism was of greatest importance in cattle *O. lambertii* was the predominating species. In the present investigation both cattle and horses showed some reluctance to eat *A. earlei,* but this reluctance was much more readily overcome in cattle than it was in horses. After the natural distaste for the plant was overcome horses proved to be much more susceptible than cattle. Such results are in accord with the common opinion of ranchmen in the region of the Davis Mountains, which holds that the disease runs a much more rapid course in horses than it does in cattle, but that the former animal is the least liable to become affected. Therefore, from an economic standpoint *A. earlei* bears more resemblance to *O. lambertii* than it does to *A. mollissimus.*

Many ranchers are of the opinion that a large proportion of the animals that eat *A. wootoni* do so after they have first acquired a taste for *A. earlei;* from which it is assumed that *A. wootoni* becomes a greater hazard when a number of "locoed" cattle are on hand. From the experimental work it is evident that an acquired taste for *A. earlei* does not necessarily imply that the taste will be extended to include *A. wootoni.* Of the six animals which had been used in previous experiments with *A. earlei,* only one sheep and one cow ate *A. wootoni* with avidity. Some of them preferred death by starvation to eating *A. wootoni,* in spite of the fact that they had readily eaten *A. earlei* in previous experiments. On the other hand the taste for *A. earlei* is retained and becomes evident upon moderate scarcity of other food.

The symptoms of locoism may disappear to the point of becoming unrecognizable as long as an animal remains quiet, but when an animal

is subjected to strenuous muscular exertion a nervousness generally reappears. It is, therefore, doubtful whether a complete recovery ever occurs. Furthermore, recovery does not appear to increase the animal's tolerance of the toxic principle. On the contrary the little evidence which is available on this phase of the subject indicates that there is a more or less permanent union between the toxin and the central nervous system, which renders the animal more susceptible to a second attack of the disease.

Starvation was recognized as an important factor in the terminal stage of the condition, as all food was refused during the short period of cerebral depression which preceded the fatal termination. However, the addition of concentrates to the regular ration or loco plants and hay proved that starvation or malnutrition is not an essential factor in the production of toxic symptoms, prior to a critical stage of the condition. It is of interest to note that when the starvation factor was eliminated in the early stages of the condition less loco plant was required to produce locoism than was required when the ration consisted of loco plant and hay. These results may represent another reflection of varied susceptibility. On the other hand the increased metabolism associated with the nutritious diet may have been an aid to the assimilation of the toxic principle. The animals that were fed the concentrates in addition to the loco plant and hay were older animals, and may have had a previous contact with the plants. However, this factor needs no consideration in the case of five of the seven animals employed in this phase of the investigation, as they were imported from a loco-plant-free area a short time before being placed in the experiment. The other two animals may have eaten some loco plants, but if so, the amount was too small to produce noticeable symptoms and the fact that they ate the loco plant with reluctance at the begining of the experiment is strong evidence that they were not "loco eaters."

The diagnosis of locoism should not prove difficult providing the habits of the animal are known and observations can be made on the living subject. On the other hand, a diagnosis from post-mortem findings alone may be associated with considerable uncertainty. Omitting the possibility of a change in the pregnant uterus, the ulcerations of the fourth stomach may have some significance, but the injury to the pyloric mucosa is quickly repaired with but little cicatrization after the habit of eating loco plant is discontinued. Furthermore, ulcerations of the pylorus are observed in other diseases and therefore can hardly be considered as specific for locoism. The changes observed in the central nervous system are also of transitory nature, having been found to disappear as early as two weeks after an animal was deprived of the plant and a nutritious diet supplied. The fact that these morphologic changes in the central nervous system disappear long before the symptoms subside indicates that other changes must have occurred. Whether or not these changes can be demonstrated by further study and a more specialized technique remains to be seen.

The inflammation of the eyes of the cattle was attributed to the dust from the plant, since the dust is extremely irritating to the eyes of man.

The nature of the dust is not known but is thought to be particles of pubescence. Men engaged in grubbing loco plants frequently experience an inflammatory condition of the eyes which is of longer duration than is generally experienced from dust of other sources. The regular assistant of this laboratory has been subjected to daily mild exposures of the dust since the investigation began. As time passed it became evident that he was becoming more susceptible to the irritating effects of the dust and since the toxicity of this group of plants for man is unknown it was deemed advisable to guard against possible serious injury by the use of a dust protector and goggles.

That possible toxic effects may develop in man as a result of continuous handling of the loco plants over long periods of time should not be overlooked. During the progress of the investigation ground loco plant was desired for some of the experiments. During the process of grinding it was necessary for the writer and the assistant to subject themselves to unusual exposures of the dust from *A. earlei* for a period of about two hours. Before the grinding was completed an intense irritation of the mucous membranes of the eyes and upper respiratory tract was observed. There was a dry sensation of the mucous membranes of the eye which was soon followed by excessive lacrimation. An intense congestion of the mucous membrane and sclerotic coat soon developed. Although no further exposure to the dust occurred in the case of the writer and very little in the case of the assistant, the inflammation did not entirely subside for over a week. Inhalation was accompanied by mild sensations of pain, and a bronchial cough developed. Both conditions continued for three or four days. A hyper-sensitive condition of the skin developed in about three hours after the exposure. The scalp was particularly sensitive, and a sensation of pain was experienced by rubbing the skin of any part of the body. The hyperesthesia was accompanied by headache and malaise which were continued for twenty-four to thirty-six hours. A similar sensitive condition of the skin is sometimes observed in cattle before marked symptoms of locoism develop. In such cases stroking the hair of the back contrary to its normal trend is associated with evidence of pain. The writer's experience with this condition suggests an anaphylactic shock, but owing to the fact that the hyperesthesia persists in cattle for days, and in some cases weeks, the most logical explanation for this condition is probably one of direct stimulation of the cutaneous nerve endings.

CONCLUSIONS

The toxicity of *A. earlei* and *A. wootoni* was established and was not destroyed by drying. The two plants are about equal in toxicity.

Cattle, sheep, and goats show a greater reluctance to eat *A. wootoni* than *A. earlei.*

The susceptibility among animals of the same species is quite variable.

The susceptibility of cattle, sheep, and goats is about the same. Horses are much more susceptible than cattle though they are more

averse to eating the plants.

Less loco plant was required to produce a critical stage of locoism when concentrates were added to the ration than was required when the ration consisted of loco plant and hay.

The milk of animals suffering from locoism did not produce symptoms of locoism in their calves.

The symptoms produced by feeding *A. wootoni* are practically identical with those caused by feeding *A. earlei*, and resemble the established symptoms of locoism produced by eating other species of loco plants.

The clinical manifestations of the disease in goats were quite different from those in other animals.

In cattle, abortions are caused by feeding *A. earlei*, but fertility is not impaired in either cattle or goats.

In pregnant cows an edema of the foetal membranes and an increase in the amount of amniotic fluid may be associated with eating *A. earlei*. This condition is erroneously called "water belly" by the ranchmen.

Conjunctivitis, keratitis, and excessive lacrimation are associated with locoism.

The maximum toxic effects may not appear until several weeks after an animal is deprived of *A. earlei*.

The gross and microscopic pathology produced by feeding *A. earlei* is practically the same as that produced by feeding *A. wootoni*.

Ulcerations of the pylorus were frequent, although not diagnostic lesions of the disease.

A definite gross pathology was not observed in the central nervous system.

Edema of the nerve cells in the central nervous system was observed. This change was of a transitory nature and disappeared long before the symptoms of the disease.

The dust from *A. earlei* and *A. wootoni* is very irritating to the eyes and the upper respiratory tract of man. The complete toxic syndrome for man is unknown. Therefore prolonged exposures to the dust from this source should be avoided.